

Geologic Resource Evaluation Scoping Summary

Salinas Pueblo Missions National Monument, New Mexico

This summary highlights a geologic resource evaluation scoping session for Salinas Pueblo Missions National Monument held in Albuquerque, New Mexico, on March 29, 2006. The NPS Geologic Resources Division (GRD) organized this scoping session in order to discuss geologic resources, address the status of geologic maps and digitizing, and assess resource management issues and needs. Participants at the meeting included GRD staff, staff from Salinas Pueblo Missions and Petroglyph National Monuments, and cooperators from the US Geological Survey, New Mexico Bureau of Geology and Mineral Resources, and Colorado State University (table 1).

Table 1. Scoping Session Participants

Name	Affiliation	Phone	E-Mail
Tim Connors	NPS Geologic Resources Division (geologist)	303-969-2093	tim_connors@nps.gov
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Tobin Roop	Salinas Pueblo Missions National Monument (archaeologist)	505-847-2585, ext. 38	tobin_roop@nps.gov
Ren Thompson	US Geological Survey (geologist)	303-236-0929	rathomps@usgs.gov
Mike Timmons	New Mexico Bureau of Geology and Mineral Resources (geologist)	505-835-5237	mtimmons@gis.nmt.edu
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Wednesday, March 29, involved a welcome and introduction to the Geologic Resource Evaluation (GRE) Program, including the status of reports and map products. The morning's discussion focused on map coverage of Salinas Pueblo Missions National Monument and other "quadrangles of interest" in the vicinity of the monument. In addition, Bruce Heise facilitated a group discussion regarding the geologic processes and features at the monument. In the afternoon, attendees participated in a short field trip led by Mike Medrano to view petroglyphs and basalt in the Piedras Marcadas Canyon area of Petroglyph National Monument.

Overview of Geologic Resource Evaluation Program

Geologic features and processes serve as the foundation of park ecosystems and an understanding of geologic resources yields important information for park decision making. The National Park Service

(NPS) Natural Resource Challenge, an action plan to advance the management and protection of park resources, has focused efforts to inventory the natural resources of parks. Ultimately, the inventory and monitoring of natural resources will become integral parts of park planning, operations and maintenance, visitor protection, and interpretation.

The Geologic Resource Evaluation (GRE) Program, which the NPS Geologic Resources Division administers, carries out the geologic component of the inventory. Staff associated with other programs within the Geologic Resources Division (e.g., abandoned mine land, cave, coastal, disturbed lands restoration, minerals management, and paleontology) provide expertise to the GRE effort. The goal of the GRE Program is to provide each of the identified “natural area” parks with a digital geologic map and a geologic resource evaluation report. In addition, the Inventory, Monitoring, and Evaluation Office of the Natural Resource Program Center is preparing a geologic bibliography for each of these parks. Each product is a tool to support the stewardship of park resources and is designed to be user friendly to non-geoscientists.

The scoping process includes a site visit with local experts, evaluation of the adequacy of existing geologic maps, and discussion of park-specific geologic management issues. Scoping will result in a summary (this document), which along with the digital geologic map, will serve as the starting point for the final GRE report. The emphasis of scoping is not to routinely initiate new geologic mapping projects but to aggregate existing information and identify where serious geologic data needs and issues exist in the National Park System. Scoping meetings are usually held for individual parks though some address an entire Vital Signs Monitoring Network.

Bedrock and surficial geologic maps and information provide the foundation for studies of groundwater, geomorphology, soils, and environmental hazards. Geologic maps describe the underlying physical framework of many natural systems and are an integral component of the physical inventories stipulated by the National Park Service in its Natural Resources Inventory and Monitoring Guideline (NPS-75) and the 1997 NPS Strategic Plan. The NPS geologic resource evaluation is a cooperative implementation of a systematic, comprehensive inventory of the geologic resources in National Park System units by the Geologic Resources Division; the Inventory, Monitoring, and Evaluation Office of the Natural Resource Program Center; the US Geological Survey; state geological surveys; and universities.

For additional information regarding the content of this summary, please consult the NPS Geologic Resources Division, located in Denver, Colorado. Up-to-date contact information is available on the GRE Web site at <http://www2.nature.nps.gov/geology/inventory/>.

The objectives of the geologic resource evaluation scoping meetings are as follows:

- To identify geologic mapping coverage and needs
- To identify distinctive geologic processes and features
- To identify resource management issues
- To identify potential monitoring and research needs

Outcomes of the scoping process include the following items:

- A scoping summary (this document)
- A digital geologic map
- A geologic resource evaluation report

Status of Scoping and Products

As of April 2006, the NPS Geologic Resources Division had completed the scoping process for 160 of 272 “natural resource” parks. Staff and partners of the GRE Program have completed digital maps for 68

parks. These compiled geologic maps are available for downloading from the NR-GIS Metadata and Data Store at <http://science.nature.nps.gov/nrdata>. The US Geological Survey, various state geological surveys, and investigators at academic institutions are in the process of preparing mapping products for 42 parks. Writers have completed 22 GRE reports with 18 additional reports to be completed by the end of fiscal year 2006.

Geologic Maps for Salinas Pueblo Missions National Monument

During the scoping session on March 29, 2006, Tim Connors (GRD) presented a demonstration of some of the main features of the digital geologic map model used by the GRE Program. This model incorporates the standards of digitization set for the GRE Program. The model reproduces all aspects of a paper map, including notes, legend, and cross sections, with the added benefit of being GIS compatible. GRE staff members digitize maps using ESRI ArcView/ArcGIS format with shape files and other features, including a built-in help file system to identify map units.

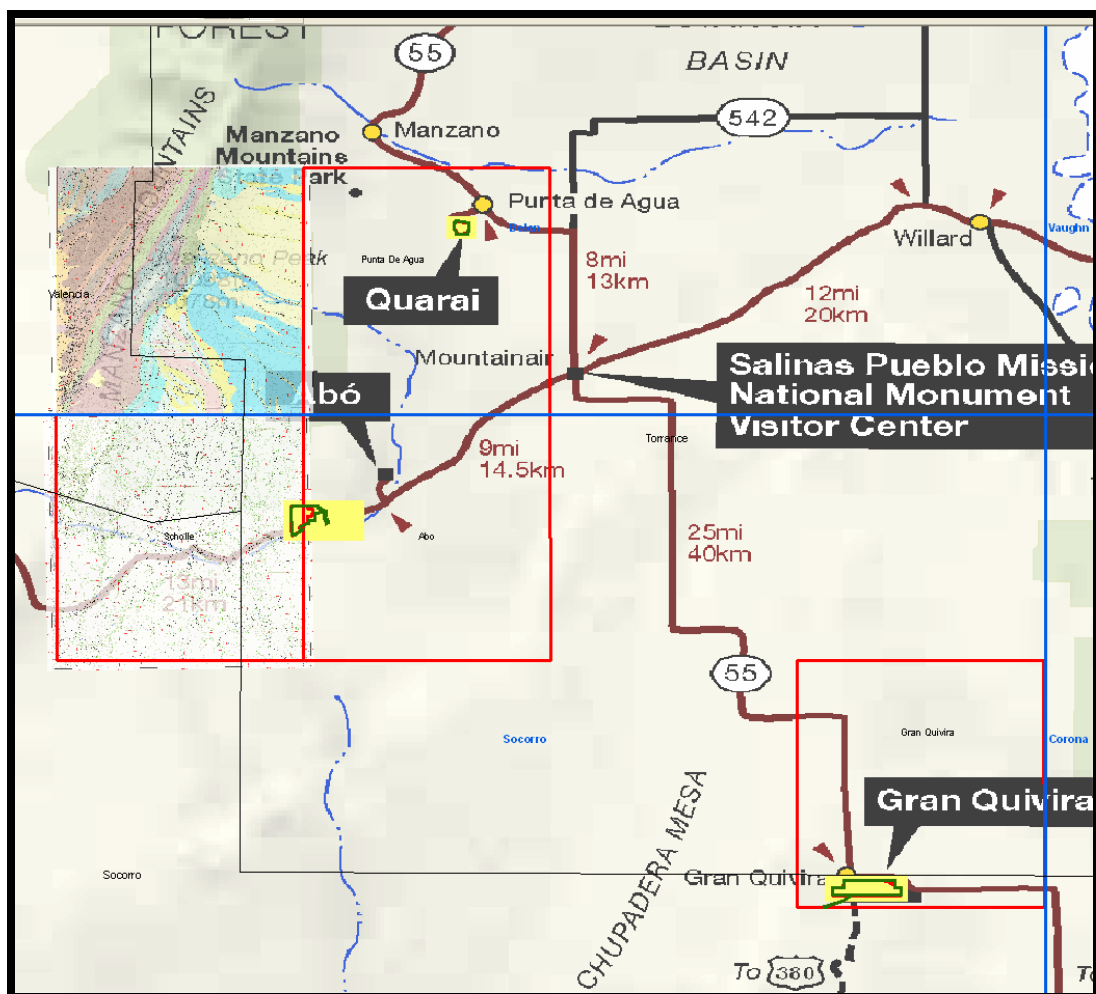


Figure 1. Quadrangles of interest for Salinas Pueblo Missions National Monument, New Mexico. Names in black indicate 7.5-minute quadrangles (scale 1:24,000); names in blue indicate 30-minute by 60-minute quadrangles (scale 1:100,000). Green outline indicates the original boundaries of the monument's three units, with accompanying red portions (within the green outlines) indicating updated boundaries. Yellow "boxes" represent the extent of geologic mapping that staff at the monument would like to have. The visitor center for the monument is simply a building and does not require geologic information for management.

Parks in Inventory and Monitoring Network have identified “quadrangles of interest” mapped at one or more of the following scales: 7.5' × 7.5' (1:24,000), 15' × 15' (1:62,500), or 30' × 60' (1:100,000). Often for simplicity, geologic map makers compile maps at scale 1:100,000 (30' × 60'), which provides greater consistency and covers more area. However, for the purpose of geologic resource evaluations, GRE staff would like to obtain digital geologic maps of all identified 7.5-minute (1:24,000-scale) quadrangles of interest for a particular park. The geologic features mapped at this scale are equivalent to the width of a one-lane road.

Map coverage for Salinas Pueblo Missions National Monument consists of four quadrangles of interest (scale 1:24,000): Punta De Agua, Abo, Scholle, and Gran Quivira (fig. 1 and table 2). The Punta De Agua quadrangle is situated on the Belen 30' × 60' sheet; the Abo, Scholle, and Gran Quivira quadrangles are situated on the Socorro 30' × 60' sheet. In addition, the Turkey Ridge Northeast quadrangle (south of Gran Quivira) is of interest to park managers because it contains karstic features that may relate to a recent discovery of a possible cave at Gran Quivira (see “Caves and Karst Features and Processes” section of this summary). In addition, the Turkey Ridge Northeast quadrangle contains the ruins of Pueblo Pardo, a moderately sized pueblo occupied somewhat contemporaneously with Gran Quivira and situated on the same geological formation.

Because park staff cooperates in a number of partnerships with agencies and partners in the corridors separating the three units of the monument, Tobin Roop, park archaeologist, mentioned that having geologic information for full 7.5-minute quadrangles would be useful; however, geologic data for a significantly smaller area surrounding the monument's boundaries is all that is absolutely necessary for resource management (see fig. 1). One unit of Salinas Pueblo Missions National Monument spans the boundary between the Scholle and Abo quadrangles. The monument's boundary has recently changed in this unit; park staff has provided updated information to Tim Connors since the meeting (see fig. 1).

In 2005, the New Mexico Bureau of Geology and Mineral Resources published a geologic map for the Scholle quadrangle (see table 2); GRE staff will digitize this open-file report. No published 1:24,000-scale geologic maps are available for the other three quadrangles of interest (i.e., Punta De Agua, Abo, and Gran Quivira). Moreover, these quadrangles of interest are very low priority for the New Mexico Bureau of Geology and Mineral Resources and the STATEMAP Program (Mike Timmons, New Mexico Bureau of Geology and Mineral Resources, written communication, April 17, 2006). However, Mike will discuss the possibility of mapping in the vicinity of Salinas Pueblo Missions National Monument with Maya Elrick, a carbonate geologist at the University of New Mexico and second author on the Scholle quadrangle. Maya Elrick may have students who could map desired portions of the Abo, Gran Quivira, and Turkey Ridge Northeast quadrangles. Maya Elrick is currently on sabbatical; hence, Mike does not anticipate that this work would begin for at least a year (and perhaps never depending upon student interest) (Mike Timmons, New Mexico Bureau of Geology and Mineral Resources, written communication, April 17, 2006). During the scoping meeting, participants concluded that an EDMAP project that focused mapping in the desired areas (see figure 1) would be the first-order priority for Salinas Pueblo Missions National Monument. Though desirable, mapping full quadrangles would be a future project.

In addition, GRE staff needs to acquire and evaluate Bates and others (1947) because it may have some useful data. As of April 18, 2006, Bates and others (1947) was out of print, but Mike Timmons is going to review a scan from the NMBG&MR archives and consult with Tim Connors about it.

In the interim of not having large-scale geologic maps for the monument, park staff could use the compiled, digital geologic map of New Mexico (GMAP 59838—see fig. 2 and table 2), though it would likely be of limited utility for resource management. GRE staff could convert digital data from the New Mexico Bureau of Geology and Mineral Resources into the NPS model for park use.

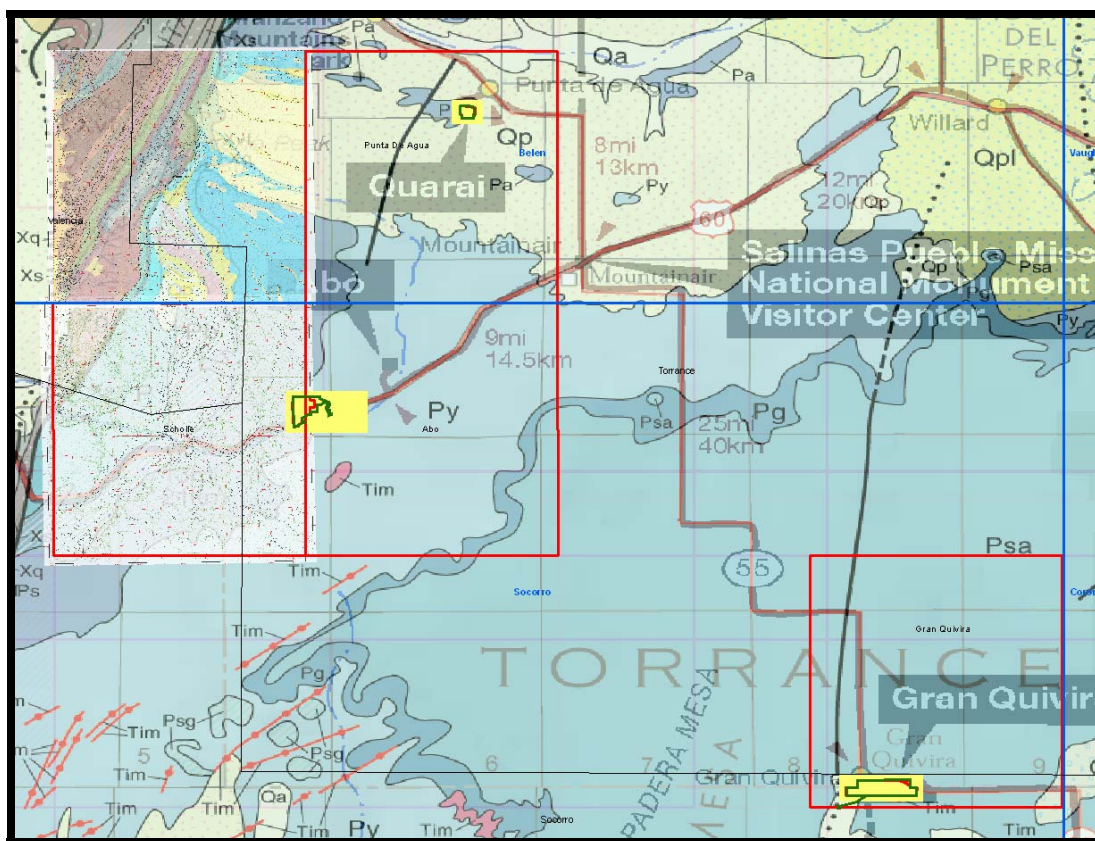


Figure 2. Geologic Map of New Mexico in the vicinity of Salinas Pueblo Missions National Monument. In the interim of not having large-scale geologic maps for Salinas Pueblo Missions National Monument, park staff could use the compiled, digital geologic map of New Mexico (scale 1:500,000) shown here as the “base map.”

Table 2. Quadrangles of Interest for Salinas Pueblo Missions National Monument

Quadrangle	Map citation	Paper	Digital
<i>GRE Plan: Digitize NMBG&MR map</i>			
Scholle	Scott, L.A., Elrick, M., Connell, S., and Karlstrom, K., 2005, Preliminary geologic map of the Scholle 7.5-minute quadrangle, Valencia, Torrance, and Socorro Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map OF-GM 99, scale 1:24,000 (GMAP 7463).*	Yes	No
<i>GRE plan: After mapping, convert NMBG&MR digital data (scale 1:24,000) into GRE model</i>			
Punta De Agua	Solicit new mapping proposals from the New Mexico Bureau of Geology and Mineral Resources, in particular, EDMAP project by Maya Elrick.	No data	
Abo			
Gran Quivira			
Turkey Ridge Northeast			
<i>GRE Plan: Evaluate NMBG&MR map</i>			
Gran Quivera	Bates, R.L., Wilpolt, R.H., MacAlpin, A.J., and Vorbes, G., 1947, Geologic map and structure sections of the Gran Quivera quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 26, scale 1:125,000 (GMAP 73259).*	Out of print	
<i>Interim GRE Plan: Convert NMBG&MR digital data (scale 1:500,000) into GRE model</i>			
Entire state	New Mexico Bureau of Geology and Mineral Resources, 2003, Geologic map of New Mexico: Socorro, New Mexico Bureau of Geology and Mineral Resources, scale 1:500,000 (GMAP 59838).*	Digital data available	

*“GMAP” numbers represent identification codes associated with the GRE database.

Geologic Resource Evaluation Report

Geologic Resource Evaluation reports include sections about geologic resources of concern for management (referred to as “issues”), geologic features and processes, the park’s geologic history, a map unit properties table that highlights the significant features and resource concerns for each map unit in the park, references (different from the bibliography), and various appendices (e.g., map graphics and scoping summary). This document (scoping summary) will serve as a starting point for information to be included in the final GRE report that will accompany the digital geologic map for Salinas Pueblo Missions National Monument.

Geologic Features, Processes, and Issues at Salinas Pueblo Missions National Monument

The scoping session at Salinas Pueblo Missions National Monument provided the opportunity to capture a list of geologic features and processes operating in the monument, which will be highlighted and expanded in the GRE report. Some of these features and processes may be of management concern.

Cave Features and Processes

During the planning phase for the backfilling of an excavation site at Gran Quivira, park staff noticed unusual cracks that appeared to be the result of subsidence. The site drapes across a series of igneous dikes, and differential subsidence occurs between these dikes and the limestone and gypsum units. Marc LeFrançois conducted some follow-up research of historical documents (e.g., NPS 1932 report by Frank Pinkley) that made reference to caves and “blowholes.” Evidence indicates that the location of blowholes determined where treasure-hunting parties sited their subterranean shafts and excavations to locate places believed to contain hidden treasures of Spanish gold. Regardless to the veracity of the legend, the cave (if it does exist) is likely to have cultural significance with Spanish and Native American cultural material. This assumption is based upon a known cave site 15 miles (24 km) due east of Gran Quivira that was used by an indigenous group of the same ethnographic association; this cave is known to contain extensive Native American rock art. The ethnographic associations of Pueblo Pardo to Gran Quivira and Abó are known (Toulouse, 1960). Pueblo Pardo was also a *visita* of the Gran Quivira mission. Recent research (i.e., Ball and others [2005]) identified a series of anomalies (possible caves), in particular under Mound 7 Pueblo.

Toulouse, J.H., and Stephenson, R.L., 1960, Excavations at Pueblo Pardo—Central New Mexico: Museum of New Mexico Papers in Anthropology, no. 2, p. 3, 38.

Ball, L.B., Lucius, J.E., Land, L.A., Kress, W.H., and Teeple, A.P., 2005, Characterization of near-surface geology using multiple surface geophysical techniques at the Gran Quivira ruins of Salinas Pueblo Missions National Monument, New Mexico [preliminary draft]: US Geological Survey Scientific Investigations Report, 46 p.

Another line of research using aerial photos would show lineaments (fracture system) that could indicate cave locations. Ron Kerbo could assist park staff with this.

Evidence points to the existence of a cave under the pueblo; however, no known entrance to the cave exists. Evidence includes a blowhole located just west of Mound 7 Pueblo, which visitors used to “enjoy” (e.g., allow the “wind” to suspend their handkerchiefs) before maintenance staff involuntarily plugged the hole sometime during the 1980s. Park staff needs to find the exact location and dimensions of the original blowhole and reopen it in order to restore airflow into the cave. Staff believes this can be done using archaeological techniques. Moreover, the reburial design of the pueblo, for the purpose of preservation and protection of cultural resources, needs to consider the natural cave systems, even those altered by previous cultural activities, as park resources.

Stream (Fluvial) Features and Processes

Intermittent, spring-fed streams and some standing pools of water occur primarily in the Quarai (Punta de Agua quadrangle) and Abó (Abo quadrangle) units of Salinas Pueblo Missions National Monument. Flooding along the trails at the Quarai unit is a concern for the preservation of cultural resources.

Lacustrine Features and Processes

A Pleistocene-age “salt lake”—Lake Estancia—occurs in the vicinity of Salinas Pueblo Missions National Monument. Various investigators have studied aspects of the lake, most recently in the 1960s. Lyons (1969) describes the history of Lake Estancia in relation to significant archaeological finds in the paleo-lakeshores. Meinzer (1911) is an early but useful text describing essentially the same as Lyons (1969).

Lyons, T.R., 1969, A study of the Paleo-Indian and desert culture complexes of the Estancia Valley area, New Mexico [Ph.D. thesis]: Albuquerque, University of New Mexico, 355 p.

Meinzer, O.E., 1911, Geology and water resources of Estancia Valley: US Geological Survey Water-Supply Paper 275, 89 p.

Hillslope Features and Processes

A significant pictograph site situated underneath a substantial Abo Sandstone outcrop is threatened by erosion. This overhanging rock shelf, and the pictographs painted on it, will potentially fall one day.

Volcanic and Seismic Features and Processes

No lava flows occur at Salinas Pueblo Missions National Monument; however, the close proximity of Gran Quivira to the Valley of Fires formation at Carrizozo may result in some seismic impacts related to volcanism. In the late 1990s, a swarm of earthquakes—the Willard swarm—were felt in all three units of the monument. Other felt vibrations may be from the military activities at White Sands, New Mexico. A fault runs along the Gallinas mountain range east of Gran Quivira, and then north towards the town of Willard, where it then arcs west and south again along the eastern edge of the Chupadera Mesa, effectively encompassing Gran Quivira (US Department of Agriculture and New Mexico Agricultural Experiment Station, 1969/1970). Park staff does not know how the fault runs in the quadrangles south of Gran Quivira.

US Department of Agriculture and New Mexico Agricultural Experiment Station, 1969/1970, Soil survey—Torrance Area, New Mexico: Washington, D.C., US Government Printing Office, p. 4.

In addition, obsidian litters the area. This does not appear to be an in situ geological resource, however; rather it is a cultural one. Past humans that occupied the region probably moved the obsidian as “chip-stone tools.” The geologic source of the obsidian is unknown: ancient travelers could have acquired the obsidian through trade throughout New Mexico or culturally transported the obsidian out of the Rio Grande basin (Tobin Roop, Salinas Pueblo Missions National Monument, personal communication, May 1, 2006).

Windblown (Eolian) Features and Processes

Similar to eolian processes operating at Petroglyph National Monument, prevailing winds deposit sand at Salinas Pueblo Missions National Monument. Hence, eolian processes have implications for cultural resources through repeated cycles of burial and exposure.

Unique Geologic Features

Paleontological Resources

Possibly the most unique geologic feature at Salinas Pueblo Missions National Monument is the remains of a mammoth discovered during road building in the 1940s. Wesley R. Hurt mentions this discovery in a cultural resources report.

Hurt, W.R., 1990, The 1939–1940 excavation project at Quarai Pueblo and Mission building: Santa Fe, New Mexico, National Park Service Southwest Cultural Resources Center, Professional Paper 29, 241 p.

The Roadside Geology of New Mexico (page 234) mentions other paleontological resources occurring at Salinas Pueblo Missions National Monument (i.e., plant and vertebrate micro-fossils in the San Andres limestone); however, park staff does not think these exist in any great significance.

San Andres Formation

Investigators are studying the San Andes (limestone) Formation for possible hydrocarbon. Past investigators have identified the anomalous, low-viscosity material found within the geologic structure (including the ruins architecture) as everything from water to fatty residue resulting from the degradation of human bodies (Gran Quivira is basically a very large cemetery). Where the formation is deeply buried, Bates and others (1947) identifies the San Andres Formation as oil and gas producing; where it is thinly buried, such as within the Gran Quivira quadrangle, it is not identified as such. However, in 2003, Phillip Wilson (Salinas Pueblo Missions National Monument, chief of resource management) asked Mary Slater (Bandelier National Monument, conservator) to perform an analysis of the material where it appeared in the soil within the convento stable area. This analysis identified the material as an artificial hydrocarbon, probably mastic resin originating in Spain and brought to the missions (this material was heavily used for a variety of purposes during the colonial period). The analysis did not take into account the extensive quantities of the material found throughout the site or the dynamic nature of the material, which would have immediately rejected any possibility for an artificial source. In short, the Slater report did not consider the full extent of the anomaly, working from assumptions based on information provided by staff at Salinas Pueblo Missions National Monument (at the time, it was thought that the material only existed in isolated locations within the mission complex, when in fact it is widespread throughout the site. Nevertheless, the Slater analysis does correctly identify the material as an organic hydrocarbon, and the report did recommend additional analysis to better define the chemical structure of the material. In 2003 Peter Scholle (New Mexico Bureau of Mines and Mineral Resources, state geologist) collected a surface sample of the San Andres limestone among the Gran Quivira ruins and sent the sample to GeoChem Laboratory in Houston. GeoChem did identify the limestone as a hydrocarbon source rock, although in very minute quantity (probably due to the rock's exposure to air for a very long time). Currently, staff at Salinas Pueblo Missions National Monument is awaiting another analysis report from the University of Arizona, based on a controlled sample extracted from the Mound 7 Pueblo architecture.

Bates, R.L., Wilpolt, R.H., MacAlpin, A.J., and Vorbe, G., 1947, Geology of the Gran Quivira quadrangle: New Mexico Bureau of Mines and Mineral Resources Bulletin 26, 49 p.

Broadhead, R., 2003, Source rock character of San Andres Formation, Gran Quivira National Monument: Letter [March 24, 2003] to New Mexico State Geologist Peter A. Scholle, 2 p.

GeoChem Laboratories, 2003, Outcrop sample from Gran Quivira National Monument, NM: Houston, Texas, GeoChem job number 4523 [March 19, 2003], 11 p.

Slater, M., 2001, Analysis of soil samples from Gran Quivira, Salinas Pueblo Missions National Monument: Los Alamos, New Mexico, National Park Service report, 12 p.

In addition, Marc LeFrançois mentioned other references that note a “petroleum-like odor” when a team cracked open some of the stones at Gran Quivira (Marc LeFrançois, Salinas Pueblo Missions National Monument, written communication, April 12, 2006).

Disturbed Lands

Small-scale quarrying of flagstone has occurred within monument boundaries prior to NPS acquisition; park staff is currently reclaiming these disturbed sites.